AN INTERESTING SCIENTIFIC CONTROVERSY.

WILFORD'S

EVOLUTION OF SOUND

Severely attacked by Prof. R. L. Brockett, A. M., Professor of Physical Science in Western Maryland College, Westminster, Md.--A Scathing and Characteristic Rejoinder by Wilford.--Strong Objections Urged Against the New Theory of Sound by Prof. I. L. Kephart, A.M., of Lebanon, Pa.--Wilford's Reply. The President and Faculty of a University admit the "Complete Overthrow of the Undulatory Theory."

Shortly after publishing **The Problem of Human Life,** of which **Evolution of Sound** forms a part, Rev. Dr. L. W. BATES, of Lynchburg, Va., heard of the work, and sent to us for a copy. On examining it, he was so much pleased with WILFORD'S arguments, that he wrote us a letter highly commending the book, and volunteering to aid us by his influence in bringing the work into notice. This induced us to send him a copy of **Evolution of Sound,** which we had published separately, embracing WILFORD'S novel arguments against the undulatory or wave theory, with a request that he send it to the most competent Professor of Physical Science known to him, for critical examination and review. He accordingly sent it to Professor BROCKETT, and so informed us.

After about a month had elapsed, he received a reply from Professor BROCKETT in the shape of a somewhat severe review, not only condemning the book as "an utter failure," but calling in question the author's motives in writing it. Dr. BATES at once copied the salient portions of the review, and sent them to us to hand to WILFORD, that he might know the kind of arguments he would have to meet. We passed the review to WILFORD, with a request that he should write out a suitable reply to this initial assault upon his work, and permit us to publish it with Prof. BROCKETT'S review, in pamphlet form, for the benefit of the public, and we so intimated to Dr. BATES.

But it seems that Professor BROCKETT, on learning through Dr. BATES of WILFORD'S intentions, refused to let his review be published, though urgently solicited to do so, which, of course, compelled the Doctor, out of courtesy to the Professor, also to withhold his consent to its publication, though greatly desiring to see what reply WILFORD could make to these raking criticisms.

Under the circumstances, therefore, regarding Professor BROCKETT'S course as not only contrary to the pretentious claims of scientists in seeking for nothing but the truth, but cowardly in the extreme in refusing to allow his criticisms to see the light after bitterly assailing the author's motives, and after skillfully trying to prejudice Dr. BATES' mind against a book he had so favorably recommended, we resolved to assume the responsibility, sieze and confiscate this battery of flying artillery, so adroitly aimed at one of our principal outworks, as contraband of war, and publish to the world Professor BROCKETT'S review, *verbatim et literatim*, as received (marks of ellipsis included), along with WILFORD'S reply, not only as a warning to others who might feel disposed to attack this work, but to allow the unscientific masses to judge for themselves as to just how much confidence should be reposed in the authoritative opinions of at least one professor of physical science.

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Professor Brockett's Review.

"I have carefully read it [*Evolution of Sound*], —given it much and close examination,—and my conclusions are that the book, as an argument against the undulatory theory of sound, is an utter failure. It is ingeniously written, is certainly the work of a man who has a thorough knowledge of the subject, but who covers up his weak points with a great flow of language, and makes so many bold utterances about overwhelming his opponents, that readers who are not *au fait* in the science of acoustics are apt to be misled. His hypothesis of corpuscular emissions is exceedingly defective, and requires so many modifications to meet particular cases, that it needs only to be stated to enable one to find insurmountable objections. 'Wilford' himself admits that there are difficulties, but consoles himself that it is the only refuge, the current theory being overthrown.

"The greatest objection I have to the book is, that the author uses the accurate knowledge he possesses (for what reason I can not tell) to teach error. This is a charge no one should make without proof. Let me produce it. In the first part of the 'Review,' where he labors to show that the pulsations of a sonorous body do not and can not disturb the air as acousticians claim, and illustrates by showing that he could not, in a closed room, with a fan, cause a gas-light to flare twenty-five feet off, under five seconds of time, and with all the effort of 'one-man power'; and, in a triumphant way, asks how the prong of a tuning-fork could throw off air-waves, when it only moves eight inches a second, and set in motion another tuning-fork 180 feet off tuned synchronously, while his fan moved over an arc of seven feet and could not cause air-waves to be felt only twenty-five feet [away], and then only after the lapse of at least five seconds.

"Now there is no analogy whatever between the motion of the tuning-fork and that of the fan, and he must have known it. The fan moves seven feet and the fork eight inches, he says, in a second; and his argument is that as the air, by its mobility, moved around and closed up so easily after the fan as not to disturb the rest of the air, that it is impossible to believe that the tuning-fork, that moves only eight inches in a second, could disturb the air at all. Let us consider this. All air-waves are not sound-waves. When we wave our hand, or move a fan, or in any other way move the air, we produce air-disturbances or waves; but *sound-waves* are only produced by the motion of *elastic bodies giving instantaneous pulses*. It is true that the prong of the fork moves only eight inches in the *aggregate*, in a second; but in that time it makes 384 *pulses, every one* of which *produces a sound-wave*. His fan, with the 'one-man power,' can only disturb the air, and can not produce a sound-wave, *because it* (the fan) *is not elastic;* and, if it were, even his 'one-man power,' without the aid of machinery, would not be able to give the *requisite velocity* to produce a *sound*-wave. His fan makes one vibration or pulse while the fork-prongs make 384; the one disturbs the air by moving *slowly* through it, which disturbances are easily adjusted by the mobility of the particles; while the other, by its *instantaneous* pulses, sets in motion *sound*-waves, that pass from the elastic body as a centre outwards in all directions. Hence his sneer at acousticians when they say the prongs of the fork advance *rapidly;* and he tells us that this rapid advance is only eight inches in a second, falls short of the mark. Is not 384 pulses or vibrations rapid motion?—and is not one pulse of seven feet per second slow motion in comparison? If Wilford wished to state the case fairly, he would not have put it as he has. He knew better. * * * * If every movement of the air produced a sound-wave, we would live in a bedlam, and your congregation would not be able to hear you preach while the ladies were using their fans; nor does this motion of the fans interfere with the sound-waves from your voice, and their rapid motion is but slightly affected even by a strong wind.

"Wilford does not seek to tell us what a sound-wave is. He makes extracts from acousticians, and calls on his readers to observe that he is very fair; but, if you will examine the quotations, you will see that his purpose is to pick out a sentence here and there, and interpolate occasionally some qualifying remark; * * * * not to present the matter fairly, but to overthrow the current theory at whatever expense. * * * * *

"A sound-wave is produced by an instantaneous vibration or pulse of an elastic body, as a music-box, when playing under a receiver and pump out the air, *the music will cease*, or rather we will not hear it, but will be *heard again* when *the air is let in*. In like manner, by observation, we know that the air-wave is a sphere—like a soap-bubble,—because we hear the sound in every direction from the sonorous body. Having, then, these two points as data, and connect with them the known fact that only instantaneous pulses will compress the air suddenly and constitute a sound-wave, we find, then, that at every pulse of an elastic body a spherical globe of air is made at the body, that vibrates to and fro, but does not advance; but, owing to the structure and properties of the air, not necessary to enumerate here, this sound-wave sets in motion—forms—another sound-wave, and it another, and so on, sometimes to the distance of many miles. When, then, we hear the sound of a bell miles away, or the whistle of a locomotive, it is not the sound-wave that was made at the place where the bell or the locomotive is, but it is the sound-wave made of the air where the listener is. * * * It is not the air that has traveled over the intervening space that strikes the tympanum of the listener, but the air around the listener that has been set in motion by the advance of the series of sound-waves, which stops only when their force has been expended. This rapid advance of the *form* of the wave is the reason that winds affect so little their progress; besides, elastic fluids, as air and gases, pass in currents through each other without creating but little disturbance.

"Now, any one can see that if these waves are made as claimed, the air all around the circumference of the sphere must be compressed, and the air in the interior must be rarefied. Sudden compression of the air causes heat, and rarefaction causes low temperature. This I can show you with a piece of apparatus belonging to the college, by means of which I can compress the air and ignite tinder, causing it to burn freely; and yet Wilford has the hardihood to use ridiculous phrases in alluding to these condensations and rarefactions, as if they had no existence in fact.

"All of our experience goes to show that the

distance sound travels, and the distinctness with which we hear it, depends entirely upon the condition of the air. The more homogeneous the air is, the better medium is offered to the progress of the sound-wave. As we ascend through the air, the sound grows feebler; and, at the tops of very high mountains, pistol-shots are no louder than pop-guns make at the base.

"But besides all this, and a plenty more that might be written, the undulatory theory of sound is established mathematically. All the phenomena of sound have been examined in connection with the current theory, and mathematical formulas have been applied in the most rigid manner; and, in every instance (sometimes correcting error, however), the theory has proved sufficiently able to meet every case.

"His cheapest game would have been to apply his hypothesis to the phenomena of light, because it will give, in some instances, a plausible explanation; though many of the phenomena—notably that of refraction—it does not and can not explain; and even Sir Isaac Newton, the originator of the corpuscular theory of light, admitted his theory did not satisfactorily account for the phenomena. * * *

"I find Dr. Drinkhouse [editor of the *Methodist Protestant*, Baltimore, Md.] has commented favorably upon the part entitled *The Problem of Human Life*. I do not know anything about that part of the book; but if he expects any help in his Problem, by showing that sound is made of corpuscles of matter, I fear his solution of the Problem is not a correct one."

Wilford's Rejoinder.

OFFICE OF HALL & CO.,
NEW YORK, Jan. 23, 1879.

REV. DR. BATES.

Dear Sir: Your letter to Hall & Co., inclosing copious and verbatim extracts from Prof. Brockett's review of *Evolution of Sound*, was handed to me for my examination and reply. Allow me to thank you for the interest you have taken in securing so competent a scientist to review the work, and one, too, who has proved himself not afraid to risk his reputation as a physicist and acoustician on the venture he has made; and I here place it to his credit that he is the first scientific investigator who has had the courage to attack these arguments against the current sound-theory, though the monograph has been in the hands of hundreds of professors of physical science and scientific journalists for months.

I must say, however, in all frankness, that I am surprised, no less than gratified, that this is the best that can be done in favor of the wave-theory and the worst that can be said against *Evolution of Sound*, by a skillful and efficient professor of physics. That he has done his best to convince you "that the book, as an argument against the undulatory theory of sound, is an *utter failure*," there can be no doubt; and the very fact that he has "*carefully read it*,—given it *much* and *close examination*,"—is conclusive on its face that had there been weaker or more vulnerable points to assail, he would have selected them in preference to the line of argument chosen. Hence, in meeting this assault, I shall feel that I am not wasting my time on matters of trivial importance.

But first let me say I forgive the Professor for his personal and unkind thrusts, virtually charging the author, though admitting his "thorough knowledge of the subject," with positive dishonesty in using "the accurate knowledge he possesses * * * *to teach error*," and who "covers up his weak points with a great flow of language," in order to mislead the readers of his book "who are not *au fait* in the science of acoustics," even accusing him with misrepresenting the authorities he quotes by a purpose to "pick out a sentence here and there, and interpolate occasionally some qualifying remark; * * * *not to put the matter fairly*," &c.

Although I forgive, I will not forget; and will only say here that I defy any man to place his finger on a single quotation in the hundreds made in *The Problem of Human Life*, including *Evolution of Sound*, which does not fairly represent the meaning of the author cited. An educated man ought to know that explanatory interpolations, thrown into a passage quoted, are entirely allowable, to save quoting the context or to avoid much longer explanations afterward, provided such interpolated remarks are duly *bracketed*. But enough of this.

I now come to the subject-matter of the review, and I am only stating what you, no doubt, have already observed, when I say that the entire argument is devoted to a single phase of the sound-question; and, though variously elaborated, involves but one assumed principle or law of science, namely, *that there are two kinds of air-waves*, differing from each other in the most essential characteristics,—one kind, such as those produced by a *fan*, traveling only about five feet in a second and only capable of reaching to a distance of twenty-five or thirty feet in a still room; and another kind, called "sound-waves," produced by the motions of a tuning-fork's prong or other vibrating sonorous body, and of such an entirely different nature that they are capable of making headway through the atmosphere at a velocity of 1120 feet a second, and to a distance, often, of many miles.

The reason for Professor Brockett selecting this phase of the discussion, and devoting his entire review to it, is apparent. This law of *two kinds of air-waves*, with the essentially different characteristics just pointed out, lies at the very foundation of the wave-theory of sound, and without which it would have no existence, as every tyro in science knows; and this law being seriously assailed in *Evolution of Sound*, he saw that unless it was rescued from the attack, the whole undulatory hypothesis must fall to the ground. Hence, he chose to direct all his force to this single aspect of the question.

I make no objection to the way he states my argument based on the *fan* experiment; and I only wish to impress the fact upon your mind that he *admits*, as he is necessarily obliged to do, the result of that experiment as I have given it, namely, that the waves thus produced travel only at a very slow speed, say about five feet in a second, and to a distance of only about twenty-five or thirty feet in a still room; while he attempts to account for it by saying: "His *fan* makes one vibration or *pulse* while the fork-prongs make 384; the one disturbs the air by moving *slowly* through it, *which disturbances are easily adjusted by the mobility of the particles*, while the other, by its *instantaneous pulses*, sets in motion *sound-waves*."

As he has thus admitted the correctness of my explanation of the fan experiment, I now propose to show that it is the *fatal* though *unavoidable* admission of his review, and that by it alone he has annihilated the wave-theory of sound, as well as his entire argument, for, by this admitted fact of the fan sending off air-waves at a very low velocity, it will be conclusively proved that the so-called "instantaneous pulses," or motions of the tuning-fork's prong, to which he so repeatedly calls your attention, can not by any possibility send off air-waves any swifter in proportion to their own rate of velocity than can the motions of the fan. He has selected the battlefield after "much and close examination," and upon it shall the battle be fought.

Not to be too prolix in this prefatory part of my argument, but which is of the utmost importance as a foundation for what is to come, let me say that if you should ask Prof. Brockett the question, he would tell you unhesitatingly that these two kinds of air-waves are essential to the existence of the wave-theory; and he would further admit that if I shall succeed in demonstrating beyond question that the air-waves generated and sent off by the movements of a tuning-fork's prong can not travel any faster than those generated and sent off by the fan, then the wave-theory must necessarily break down.

To this task, therefore, I now set myself; and I pledge to you my word of honor, and obligate myself in the most solemn manner, that if I do not succeed in this rejoinder in satisfying your mind beyond the shadow of a doubt, and the minds of any three unbiassed gentlemen you may select, that this foundation-law of *two kinds of air-waves* is absurd in reason and false in fact and science, then I will publicly renounce and denounce *Evolution of Sound* as a fallacious work from beginning to end, and will immediately, upon an adverse decision, cause the plates to be destroyed.

My first appeal shall be to logic and reason, without any special reference to this review, but only as relates to the probability of the existence in Nature of any such essentially different varieties of air-waves as the theory requires; after which I will give the positive proof, in various ways, that such different varieties of air-waves can have no existence in fact, thus shattering the wave-theory on its own chosen ground.

It is well known to every student of physical science that sound travels through all solid and liquid bodies with even greater velocity than through air. Professor Tyndall says:—

"The velocity of sound in *water* is more than *four times* its velocity in air. The velocity of sound in *iron* is *seventeen* times its velocity in air. The velocity of sound along the *fiber of pine wood* is *ten times* its velocity in air."—*Lectures on Sound*, p. 47.

Let us now see how this *law* of two different kinds of air-waves, upon which the very life of the wave-theory depends, will behave, when we try to harmonize it with the propagation of sound through *water* and *iron*. But before testing it thus, I wish barely to call your attention to this most suggestive fact, that in all the published works on sound not one single writer has ventured to discuss or even allude to the nature of this indispensable wave-motion in water, iron, and other solid and liquid bodies. They cautiously steer entirely clear of these ugly questions of "condensations," "rarefactions," "wave-lengths," oscillations "to and fro" of the wave-particles, and "superpositions" of a number of systems of waves at one time passing through iron, although they talk and write learnedly and confidently enough of all these things taking place in the passage of sound through air. Why this apparently studied and universal silence in relation to sound-waves in water and iron, when these writers know very well and admit that sound travels with greater facility and with many times greater velocity through them than through air? I will tell you the reason, whether they think of it or not. Air is *invisible;* and it becomes entirely convenient to fabricate and formulate all this scientific nonsense about atmospheric "condensations," "rarefactions," "oscillation of the particles to and fro," "superpositions," &c., thinking, as they must, if they think at all on the subject, that the absurdity of the thing can not be detected, since the atmosphere can not be seen. But should they attempt to apply their philosophy of "to and fro" motions of the particles to iron, or even water, where the particles are visible under the microscope, they must know, if they reflect at all, that the shallow deception would be exploded, and that all this pretended wave-motion as the principle of sound-propagation would be at once demonstrated to have no existence in fact. But as long as they can keep you away from *iron*, or anything you can examine with the microscope while sound is passing through it, and confine your attention to a substance like the air that can not be seen, there is no end to their rhetoric about this "*spherical globe of air*" "like a soap-bubble," as Prof. Brockett expresses it, which forms in a circle all around the tuning-fork!

What a pity that some one of his students should not request him to give an ocular demonstration of his theory of air-waves by generating a "spherical globe" of *iron* or *water* "like a *soap-bubble*," and let them look at it under the microscope! These *bubbles* ought surely to form in *water* and *iron*, if they do in *air!* But there is not the least danger that advocates of the wave-theory of sound will ever perpetrate such a stupid piece of self-stultification as even to allude to these little *globes* and *spheres* caused by sound in connection with any substance that can be seen, knowing, as they must, that such a legitimate application of their philosophy to visible bodies would instantly explode the "soap-bubble" fraud, and turn the whole wave-theory into ridicule!

But now let us try to test the truth of this theory in *air*, by applying it to *water*. First, then, I state the logical and incontrovertible principle, which no one will question, that if *air-waves* constitute *sound-waves* in *air*, then *water-waves* constitute *sound-waves* in *water*, and *iron-waves* constitute *sound-waves* in *iron*. One has no need of a scientific education to comprehend or see the force of this. Then, as *sound-waves* in water must be *water-waves*, just as sound-waves in air must be air-waves, it involves the unavoidable necessity of two kinds of water-waves, the same as Prof. Brockett's two kinds of *air-waves*,—one kind slow (from two to thirty feet a second), and the other kind fast (4,500 feet a second),—one kind *visible* and the other kind *invisible*, even under the most powerful microscope,—one kind with an *amplitude* or depth of furrow equal always to *one foot* for every *ten feet of wave-*

length, while the other kind is devoid of all amplitude, not even enough to be observed under the microscope, since no motion of the water-particles "to and fro" takes place, and hence there are no waves, because such a thing as a system of waves without amplitude is as absurd as to talk of a *rainbow* without a *curve*, or a *straight crooked stick!*

But here the wave-theory of sound runs against an inexplicable difficulty, and one that hopelessly crushes it. In *Evolution of Sound*, at page 318, and elsewhere, I quote from the highest living authorities numerous passages declaring that *sound-waves* are "essentially identical" with *water-waves*, are "precisely similar" to them, and travel "exactly in the same way." These are the very words of an authority no less than Professor Helmholtz himself, the greatest living advocate of the wave-theory of sound. But, mark you, he said this with reference to *atmospheric* sound-waves, the thought never entering his great intellect at that instant, I will venture to say, that sound passes through *water* with much greater facility than through air, and consequently should have much more distinctly marked waves! Had this idea ever flashed across his mind that sound passes through water,—and that, too, in the form of waves,—he would have instantly seen the ridiculous plight in which he had unwittingly involved the entire wave-theory; for if sound-waves in air are "essentially identical" with water-waves, and if they are "precisely similar" to them, and if they travel "exactly in the same way," then sound-waves in water must also be "precisely similar" to water-waves, must be "essentially identical" with them, and must travel "exactly in the same way"; and hence it follows, monstrously absurd as it is, *that sound-waves in water are nothing more nor less than common water-waves!* This is inevitable, if there is any meaning in words. And thus we not only annihilate the wave-theory of sound both in air and water, but we upset all science in regard to the velocity of sound in different substances. Observation assures us that all sounds travel through water at the uniform velocity of about 4,500 feet a second, whether such sounds are of the highest pitch, having a theoretic wave-length of only *one foot*, or are the low notes of the church organ, with theoretic wave-lengths in water of over one hundred feet. But here comes Prof. Helmholtz, who authoritatively smashes this feature of science, and declares that sound-waves travel "exactly in the same way" as water-waves!

What, then, is the result? Why, simply that all observation in regard to the velocity of sound, whether in air or in water, is wrong from beginning to end; for, as sound-waves travel "exactly in the same way" as water-waves, there ought to be no uniformity at all in the velocity of sounds of different pitch, and consequently of different theoretic wave-lengths, because it is overwhelmingly established in *Evolution of Sound*, for the first time in any scientific work, that the *velocity* of all water-waves must and do vary, by the necessity of wave-motion, in exact proportion to the *wave-lengths* of any given system,—the small waves of one inch wave-length, caused by the falling of drops of water, traveling only two feet in a second; those caused by a passing steamboat, with ten feet wave-length, traveling seven feet in a second; while ocean billows, with from thirty to one hundred feet wave-lengths, travel from fifteen to thirty feet a second. (See pages 317 to 326.)

This single consideration, therefore, without the aid of another proof, overthrows the wave-theory of sound in air as well as in water, because in the only wave-motion we can see and measure, we find that an immutable law prevails, namely, that the velocity of all waves is variable and in proportion to wave-length, while sounds, whether high or low in pitch, have but one uniform velocity in any one substance, thus demonstrating that sound does not travel by wave-motion at all.

I will here venture the assertion that Professor Brockett never read this argument at all, notwithstanding his "much and close examination"; for, if he had, he would have been totally confounded by the fact that the very nature of wave-motion flatly contradicts the wave-theory of sound.

But I have not yet reached the culmination of these logical and common sense reasons for rejecting air-waves as the principle of sonorous propagation, nor have I touched upon the greatest absurdities which such an assumption necessarily involves. I have already stated the logical fact, that, if *sound-waves in air* constitute *air-waves*, as Prof. Brockett teaches, and as admitted by all writers on the subject, then *sound-waves in iron* constitute *iron-waves*. It is impossible to evade this. Further, as atmospheric sound-waves are formed by "*a small excursion to and fro" of the air-particles*, thus constituting their "amplitude," without which air-waves could not exist (see many quotations to this effect, *Evolution of Sound*, p. 78), it follows that *iron sound-waves* must also be formed by "a small excursion to and fro" of the *iron-particles*, thus constituting the necessary "amplitude" of *iron-waves*, and without which a "wave" is a nonentity! But as no such "excursion to and fro" of the iron-particles occurs, even when examined under the most powerful lenses, and consequently no "amplitude" exists in such supposed iron undulations, it demonstrates that there is no *wave-motion* in iron as the result of sound, and hence that sound must pass through iron by some other law; and if through iron then through air, as there evidently can be no two different modes or principles of sound-propagation through different substances,—one *wave*-motion, and another something else! Hence, the undulatory theory of sound, even in air, breaks down of its own inherent weakness.

Should it be said, here, that in the propagation of sound through iron the particles may move "to and fro," producing the necessary "amplitude" as required in all wave-motion, but not sufficiently to be visible under a microscope, then I answer that such *invisible* and *infinitesimal* motion, even if it occurs, would not constitute sound capable of addressing the human *ear*, because the *eye* is admittedly the most refined and sensitive of all the avenues to perception; and this being so, these supposed motions of the iron-particles, which can be so easily heard by the unassisted ear, should, if they take place at all, be plainly visible to the naked eye! But as this assumed "amplitude" or motion of the particles can not be seen when the sight is magnified a million fold, it is conclusive evidence, on its face, that such motion, if it takes place at all, is a million times too trifling to be heard! Thus, again, does wave-motion in *iron* break down; and with it, as a necessary corollary, wave-motion in *air*. Let Prof. Brockett try his hand on this problem, instead of skipping "here and there" and dealing in glittering generalities.

But here comes the most startling and monstrous of all absurdities ever taught as science; and yet it is an inseparable part of the wave-theory of sound, —a theoretic result absurd enough to cause a conscientious advocate of the undulatory hypothesis to hide his face in mortification whenever it is squarely placed before him. I will now point it out; and particularly invite Prof. Brockett's attention to it.

According to the current theory, if the *pipe* which makes the lowest tone of the church organ (16 vibrations in a second, as stated in Prof. Blacerna's recent work,) should be sounded in contact with a mass of iron large enough, this tone would travel through the mass in *actual waves*, or *bona fide undulations*, having *wave-lengths* from crest to crest, or "from *condensation* to *condensation*," of *one thousand one hundred and ninety feet!* Does Prof. Brockett believe in these *iron billows* of nearly a quarter of a mile from crest to crest, and with an *amplitude* (if in proportion to that of water-waves, to which they are "precisely similar") *of more than one hundred feet from the top of the crest to the bottom of the sinus?* He certainly does and must believe in just such prodigious *iron undulations* (minus the amplitude) unless he renounces the wave-theory of sound, of which this is one of the legitimate and unavoidable results. No man can believe in the wave-theory unless he believes in these monstrous iron-waves; and no wonder Prof. Robert Spice, one of the most competent sound-investigators and acousticians in this country, was forced to declare, when the writer laid before him this consequence of the wave-theory, that the idea of such enormous iron-waves caused by sound was a manifest absurdity, and hence that the wave-theory itself could not be true.

To a physicist I would not need to waste a single line in proving that, in accordance with the current theory, the organ-tone named must pass through iron by means of these stupendous undulations more than a thousand feet long, as measured from the center of one condensation or crest to the center of another. A professor of physical science knows that it is so, unless he has shut his eyes to the unavoidable absurdities which are the legitimate consequences of this theory. But to students who are "not *au fait* in the science of acoustics" or who are not read up in the mysteries of this *mathematically formulated* hypothesis, it may not be so plain. It shall therefore be proved in a single paragraph.

If we divide the distance sound travels in a second by the number of vibrations any sounding body makes in a second, we of course determine the wave-lengths of that or of any other sound of a given pitch, since the pitch of any tone is caused by the number of vibrations of the sounding body in a second which produces it,—while, according to the theory, each vibration sends off a wave, whether in air, water, iron, or whatever other conducting medium. Now, as sound travels in air, at 60 degrees Fahrenheit, 1120 feet in a second, and seventeen times swifter in iron, it must therefore have a velocity in iron of 19,040 feet in a second, which, divided by 16, the number of vibrations of this low organ-tone in a second, shows the wave-lengths of a sound of that pitch in iron to be *eleven hundred and ninety feet from crest to crest*, as just stated, and as any schoolboy can verify. This is a fair specimen of the beautiful theory I have the honor of opposing!

But the most startling feature of this "scientific" hypothesis remains to be stated. It presents us with the miraculous anomaly of iron *undulations*—actual *waves*—nearly twelve hundred feet long from crest to crest, but without an *amplitude* or depth of *furrow* of *even the one millionth of a hair's breadth!* One would really think that a professor of physical science, competent to retain a chair in a respectable college and who possesses a particle of pride or intellectual snap, would be ashamed to have the students know that he was capable of believing in a theory which involves and necessarily teaches such a monstrous and superstitious impossibility as that a certain sound passes through iron in actual *waves* or *undulations* eleven hundred and ninety feet from crest to crest, and then stultify himself and the theory by admitting, as he is forced to do, that such stupendous undulations—four times the size of the largest ocean billows—are devoid of all *amplitude*, the only thing that constitutes an *undulation!* Surely such absurd nonentities as these can not be called "waves," for, in the name of Webster's Dictionary, what is a *wave* with the *amplitude* left out? Prof. Brockett would make a capital star actor in the scientific play of Hamlet with the Prince of Denmark and all the other characters omitted!

In concluding this part of the inquiry, I now ask intelligent, common sense, thinking men, to tell me if such hypothetic philosophical monstrosities as these iron undulations without a particle of amplitude, can be scientifically or rationally called "*waves*"? If not, then sound manifestly travels through *iron* by some other law than *wave-motion;* and if through *iron* then through *air*, since, as just remarked, even Prof. Brockett, with all his "hardihood," would not venture to claim two distinct principles of sonorous propagation through different substances, lest he might thereby involve his "mathematically" formulated theory in the necessity of accounting for a separate mode of travel for every known substance.

I now come directly to the consideration of Prof. Brockett's criticisms, in the course of which I have promised to produce *positive proof* that air-waves sent off by the motion of a tuning-fork's prong can not, in the nature of things, travel any faster than can the air-waves sent off from a *fan*, or even from a *stick* of the same size of the prong, and moving through the air with the same velocity; and, in doing so, I will of course shatter the wave-theory of sound, since there can, in that event, be no air-waves corresponding in velocity to sound-pulses. I ask you to carefully note the following considerations.

In *Evolution of Sound* I make the assertion, and claim to have established its truth by many illustrations, that it is not possible for even the most skillful advocate of the current theory of sound to touch the hypothesis with his pen and write a single page in explanation of its details without being forced into self-contradictions, not from any fault of his intellect or education, but alone from the inherent absurdity of the theory, based, as it is, upon laws and principles in conflict with Nature and with one another.

I will give an illustration of the truthfulness of this charge by proving that Prof. Brockett, even in this short review, has been compelled not only to contradict himself several times and in several different ways, but to flatly contradict Tyndall, Helmholtz, and every acoustician who has written on

sound. This seems like a serious charge, but I will make every word of it good by quoting his own language.

As an introduction to this record of self-contradictions, and as a good technical joke on my learned critic, take his statement of the music-box playing under an exhausted receiver. He says: "Pump out the air, the music will cease; or *rather*, we will not hear it." Now, if there is any meaning in the language he employs, that word "*rather*" distinctly teaches *that the music does not cease, only we do not hear it!* Am I not right? Thus he admits that the *music* continues even *without air*, or after the air is pumped out; hence, musical sounds are not constituted of *air-waves*, as his whole argument aims to prove! This explanation of the playing of a music-box in vacuo is precisely what I give in *Evolution of Sound*, where I show that the sonorous pulses, generated under the receiver after the air has been exhausted, fall to the table unheard for the want of a conducting medium, just as the substantial currents of electricity will not travel without some kind of a conductor; and I have no doubt but that Prof. Brockett caught his idea of the sound continuing without the air, but unheard, by reading my exposition, which, unfortunately for his air-wave hypothesis, proved "rather" too much for him!

But here is a self-contradiction which is not technical, but one that is out and out, and entirely fatal to his theory. He admits that the aggregate rate of travel of the prong of a tuning-fork is only eight inches in a second. These are his words: "It is true that the prong of the fork moves only eight inches in the aggregate in a second." Then put this statement along with another, as follows: "Only *instantaneous pulses* will compress the air suddenly, and *constitute a sound-wave*," and it will take but a moment to point out the flattest possible self-contradiction. First, we must know, from his own use of the word, what meaning he attaches to "pulse." He evidently does not mean the repeated *starts* and *stops* of the prong while vibrating, but its *actual motion while traveling*, after starting and before stopping. We have positive proof that this is his meaning, because he calls the movement of a fan through a single sweep of seven feet a "pulse." Note his words: "Is not *one pulse* of *seven feet per second* slow motion?" Then, as the "pulse" of the fan is its actual travel "seven feet," and has nothing to do with its start and stop, it follows that the "pulse" of a prong is its actual travel *a sixteenth of an inch*, or through one of its sweeps, and has nothing to do with its start or stop! Now comes the Professor's annihilating contradiction both of himself and the wave-theory. He admits that the actual travel of the prong during a second, leaving out its starts and stops, is but "eight inches," or only *one tenth* as fast as the fan travels. And as the fan's travel is "slow motion," the prong's travel is *ten times slower*, and therefore can not be an "*instantaneous pulse*"! Now take his other statement that "Only *instantaneous pulses will compress the air suddenly*," and the bottom falls out of his whole criticism, showing that the motion of the prong, not being "instantaneous" but "slow motion"—much slower than the fan's movement—can not "compress the air" or send off waves even as swiftly as can the motion of the fan! This I call *positive proof*, and obtained directly from the highest living authority, so far, at least, as this discussion is concerned,—namely, Prof. R. L. Brockett, A.M.

Now look at the thing philosophically for one moment. What an absurd and shallow idea to advance as part of a "mathematically" formulated theory of science, that the slow motion of a prong, if it only stops after traveling a sixteenth of an inch, will send off an air-wave at a velocity of 1120 feet in a second; but if it goes on at the same rate of travel seven feet before stopping, it will only drive the atmospheric disturbance with a velocity of *five feet* in a second! Yet this is exactly what this "established" theory teaches. If the prong advances a sixteenth of an inch at the slow rate of "eight inches" in a second and stops, then off shoots an air-wave at a velocity of more than a thousand feet in a second; but if the same prong should travel on seven feet *at ten times this velocity*, and stop, then, presto! it sends a wave only *five feet* in a second, "which disturbances are easily adjusted by the mobility of the particles"! Yet just such mechanical puerility as this is taught in all our colleges as a part of physical science.

Does not reason teach any man, who pretends to think at all on questions of philosophy, if the motions of a prong, or a stick, or anything else, to a distance of a sixteenth of an inch at a given velocity shall produce a certain mechanical effect upon the air, that the same motion continued an *inch*, or a *foot*, or *ten feet*, must, for each sixteenth traveled, produce at least an equal mechanical effect? Yet this insane theory, that has been "*established mathematically*," as Prof. Brockett declares, teaches that if the prong moves a sixteenth of an inch at a velocity of eight inches in a second, and stops, it will send off an air-wave two hundred times swifter than if it moves seven feet before stopping, and *even at ten times that velocity!* No difference, according to this carefully formulated theory, how slow a body advances, if only at the rate of eight inches in a second, *so it only stops often enough*, it produces an enormous effect at *each motion* in the velocity at which it sends off air-waves; but if it does not stop but *once*, and, after moving seven feet at ten times higher velocity, its effect on the air is *two hundred times less!* Common sense would tell us that the result ought to be exactly the reverse,—the long continuous sweep producing vastly the greater effect on the air; and if a trained professor of physical science in one of our leading institutions of learning is not capable of seeing this, then intellectual culture becomes a farce, and our colleges and universities might as well be abolished at once. I declare I have very little patience with men who make great pretensions to accurate scientific knowledge, yet who can see no deeper into the common sense principles of mechanics and pneumatics than to believe in and advocate such self-stultifying nonsense.

The unvarnished truth is that Prof. Brockett does not know the meaning of the words he employs, though he uses them in strict accordance with the wave-theory. To quote him: "This is a charge no one should make without proof. *Let me produce it.*"

Take, for example, his illiterate use of the word "motion," which, above all other words in this discussion, needs to be employed correctly. Now, every schoolboy knows, or can easily know, that *motion* signifies the act of a body *passing* from one position to another. This is its primary and

universal meaning, as all vocabularies teach. It does not signify the number of *starts* and *stops* a body makes in a given time, but the actual *travel* of the body *while moving*, after starting and before stopping. But Prof. Brockett, either unaware of this true meaning of the word or else to *cover up* the "weak points" in his theory, asks you, "Is not 384 pulses or vibrations *rapid motion?*—and is not *one pulse* of seven feet per second *slow motion* in comparison?" And this, too, mark you, notwithstanding he had just admitted that the actual travel of the prong in either direction was but eight inches in a second, or *one tenth* the distance of the fan's travel. He thus erroneously supposes that the succession of numerous starts and stops of the prong constituted its "rapid *motion*" without any regard to whether the prong traveled an inch or seven feet in a second, while the *one start and stop* of the fan in a second constituted "*slow motion*," even if its travel had been a hundred feet in the same time!

There is no mistake about this meaning of the word "motion," as he employs it. If a prong only starts and stops often enough it is "rapid *motion*" if it only advances *an inch* in a second; but if it advances seven feet in a second, or eighty-four times as fast, it is "*slow motion* in comparison," because it did not stop and start a good many times on the way! Yet, if this confident critic were traveling by a train of cars, he would hardly write you that the train made "rapid motion" through the country, because he happened to be drawn by a ricketty locomotive which was compelled to stop and start every half minute! He would, no doubt, be able to catch the true meaning of the word "motion" in such a case, and see that the stops and starts, instead of constituting the train's "motion," were directly opposed to it; and had his common sense only come to the aid of his uncommon science in like manner, while trying to analyze the motions of a prong and their mechanical effects on the air, he would never have been led into the use of such "ridiculous phrases" as calling eight inches a second "rapid motion," and "seven feet a second *slow motion* in comparison"! There is one of his personal remarks I am sorry I can not quote in return: "He *knew better*"!

Now, whether the prong of a tuning-fork really moves, while traveling through one of its swings, at a rate of velocity of only "eight inches" in a second, as Prof. Brockett admits, or many times faster, it matters nothing in this argument against the wave-theory. Should it even travel at ten times this rate of speed, it would only equal the fan's velocity, which the Professor truly declares to be "slow motion." The infinite absurdity of the thing of which I complain, is in teaching, as does Prof. Brockett and as do all writers on sound, that this prong, in moving *one sixteenth of an inch only*, produces *two hundred times more mechanical effect on the air than if it moved seven feet at the same rate of velocity!* Of course, college professors have a perfect right to believe in such pneumatical and mechanical nonsense if they please, and if it suits their intellectual caliber, but they have no right to call it "science," and teach it to students as part of a "mathematically" formulated and "established" theory.

I believe I am fully justified in the assertion that Prof. Brockett has not read the book at all "carefully," or more than merely glanced at it "here and there"; for, if he had read it, why does he go into an explanation to convince you that I deny the possibility of compressing the air, and thereby generating heat? He assures you that "with a piece of apparatus belonging to the college" he can compress the air so as to ignite tinder. Yet he must have been aware, had he read the book, that you knew all about this matter, which was fully explained and admitted in *Evolution of Sound*, in which I showed that amadou could be ignited by heat thus generated. Then he adds: "Yet Wilford has the hardihood to use ridiculous phrases in alluding to *these condensations and rarefactions as if they had no existence in fact*."

Now, I protest that if this critic really read the book and was honest in making this statement, he is entirely incapable of understanding what he reads. I carefully explained the principle, and showed how the air could be condensed and rarefied, thus producing heat and cold, by the action of a piston in a tube, and made an elaborate estimate of the mechanical force it would take to condense a given quantity of air sufficiently to generate the heat required by the wave-theory, according to the estimate of Laplace. My "ridiculous phrases," therefore, were employed in exposing the "ridiculous" idea that a locust by stridulating, or moving its legs across the nervures of its wings, could exert enough mechanical force or pneumatic pressure to condense the four cubic miles of air throughout which its sound was heard, and thereby generate heat sufficient to add "one sixth" to the velocity of its sound, as the wave-theory imperatively requires! Why did not Prof. Brockett find it convenient to see this argument if he had really read the book "carefully,—given it *much* and *close* examination"? It seems to have been more in accordance with the object he evidently had in view to utterly ignore a dozen just such unanswerable arguments as this; and, in lieu of it, to accuse me of using "ridiculous phrases" about the philosophical experiment of compressing and heating the air, so well understood by all scientific students. Is this a specimen of that fairness and that paramount desire for nothing but the truth, of which professors of physical science so constantly boast And in contrast with this manifest skulking of the main difficulties, I ask any reader of my treatise on sound to point to a single consideration referred to by writers to favor the idea of wave-motion that is not fairly and squarely attacked by the writer, without showing the slightest disposition to evade or dodge the force of the arguments used.

Had Prof. Brockett done nothing else in his entire review but take up that one argument based on the stridulation of the locust, and had he tried to show how it was possible for an insect by moving its legs to compress and heat four cubic miles of air, and thus add "one sixth" to the velocity of its sound, while actually exerting a mechanical force sufficient to shake 2,000,000,000 tons of tympanic membranes, as so clearly shown to be taught by the wave-theory of sound, it would have been infinitely more creditable to him as a candid scientific investigator than to deliberately ignore it by misrepresenting the author he reviews. But you can rest assured that no critic or reviewer of *Evolution of Sound* will ever essay to break through that locust argument only to be disastrously broken in the attempt.

I now come to another positive proof, growing directly out of Prof. Brockett's admissions, that the

air-waves sent off by a vibrating tuning-fork do not constitute its sound-pulses,—an argument, by the way, against the undulatory theory, which admits of no kind of reply; and if Prof. Brockett thinks differently he is at perfect liberty to try his hand at it. To prepare for this evidence, I will first quote his exact language:—

"His fan, with the 'one-man power,' can only disturb the air, and can not produce a sound-wave, because it (the fan) *is not elastic;* and, if it were, even his 'one-man power,' *without the aid of machinery, would not be able to give the requisite velocity to produce a sound-wave.*"

Before framing my argument, however, on this fatal admission, I wish again to refer to his constant illiterate use of words. Throughout this review he uses the phrase "*elastic* body" for *sonorous* body; and in the most absurd manner denies that a fan is "elastic," when any one knows that a fan may be even many times more elastic than the stiff prong of a tuning-fork, or a bell. He evidently meant that a fan was not *sonorous.* A piece of *caoutchouc* or soft rubber is one of the most *elastic* bodies in existence; but I never heard of it being remarkably *sonorous.* This outlandish employment of a common and familiar word, and in a way entirely foreign to its signification as given in any dictionary, is certainly refreshing, coming from one of the leading chairs of a first-class college.

But the admission to which I refer, in the quotation just made, and which contradicts all the Professor has tried to inculcate in this review is, that with the aid of "machinery" attached to the *fan* its air-waves might be driven off with *increased velocity*, and thus come nearer constituting sound-waves than if the fan was propelled by "one-man power," as in my experiment. The principle thus admitted is evidently correct, as any one can soon determine, and as I ascertained in my experiment, namely, that the air-waves sent off by swinging the fan to and fro traveled with a velocity in proportion to the force applied in operating the fan. If the fan was moved with little force the air-disturbances would travel sluggishly; but if the fan was operated vigorously, with the full strength of my arm, the waves would naturally make headway through the air with increased velocity; and consequently Prof. Brockett is right in assuming that if the fan were operated by powerful "machinery" the waves generated would necessarily travel with much greater velocity. Since, therefore, he admits this principle to be correct, he thereby acknowledges the wave-theory of sound to be false from root to branch; for that theory teaches, as every one knows, that air-waves, sent off from a tuning-fork whose feeble motions a single hair will check, travel with exactly the same velocity as do the waves driven from a powerful steam siren operated by the "machinery" of a twenty horse-power engine! Thus, again, by one of the inevitable self-contradictions inseparable from the theory, the whole hypothesis that air-waves constitute sound is destroyed; for all know, as the Professor admits, that while air-waves will travel with greater velocity if greater force be applied in driving them off, every sound travels with one uniform velocity in air, whether it be the feeble sound produced by a mosquito's wing or the thundering report of a fifteen-inch Krupp gun!

My learned reviewer, therefore, by the cleverest blunder imaginable, while attempting to criticise my fan experiment, has unwittingly stumbled upon an important scientific principle which most signally lets the bottom drop out of his entire review by demonstrating that the sound-pulses from a vibrating tuning-fork must be *something* entirely different from the trifling air-waves thus put in motion,—*a something which radiates and travels, not by mechanical propulsion at all, but by its own peculiar law of conduction, and without any relation to the force which the sonorous body exerts on the surrounding air.*

How beautifully is this view of sound illustrated by the substantial current of electricity which travels through a wire by its own peculiar law of conduction at a uniform velocity of about 3,000 miles a second, without any relation whatever to the force of the battery or the rotary power of the dynamo-electric machine which generates the fluid! If physicists would pay the slightest attention to these wonderful analogies existing all around them in Nature, they would instantly cease to advocate these monstrous absurdities so inseparable from the undulatory theory.

I will not take the time here to show what a sound-pulse or sound-wave is. I have given my arguments in full on that aspect of the question in *Evolution of Sound*, at the close of Chapter V., notwithstanding Prof. Brockett, in keeping with his entire review, informs you that "*Wilford does not seek to tell us what a sound-wave is,*"—another conclusive evidence that he had not read that part of the book at all, or else that he is utterly reckless as to the statements he makes; because I there devote seven pages to the single question of what constitutes *sound*, since it was manifest that *air-waves* had nothing to do with it. In that connection it is particularly shown from many considerations, and by analyzing the relation of the five senses with one another, that there exist startling analogies between *light*, *sound*, and *odor*, and between the sensations they produce in *seeing*, *hearing*, and *smelling;* and it was thus logically proved that as one of these senses admittedly depends upon the reception of corpuscular emissions for its connection with the external world, so the others must also, or else there is no uniformity or consistence in Nature's plan. But, as usual, it was convenient for Prof. Brockett to ignore this sweeping argument by assuring you that "Wilford does not seek to tell us what a sound-wave is."

I will conclude my positive evidence that the air-waves sent off from a vibrating prong can not travel as fast, even, as can those sent off from a fan, by presenting a simple *experiment* addressed to the observation of the senses,—a class of evidence universally admitted to be more reliable than any other, provided the experiment be honestly made. As already intimated, physicists who have experimented and written on sound appear to suppose that as the air is invisible this 'soap-bubble" cheat of the wave-theory can not be exposed. But I now propose to *look* right at Prof. Brockett's *spherical globes of air* with the naked eye, and find out by a single experimental test just how much reliance is to be placed in the mathematically established hypotheses of these vaunted authorities on physical science.

The experiment is easily made by any one possessing a large tuning-fork,—the larger the better, so its vibrations are sufficiently rapid to produce tone,—and consists in the following: Fill a glass jar (the larger the better), turned top downward,

with the dense smoke of brown paper; and when the motions of the smoke, caused by the heat of the burning paper, have subsided, gently reverse the jar in front of a light window and hold the vibrating fork in it, and it will be found that every motion of the air produced by the oscillations of the prongs will be plainly visible in the undulations and convolutions of the smoke. Now, what takes place? I declare to you and to the scientific world that the air-waves thus visualized are the same precisely as those sent off by the fan's rapid oscillations, only on a very diminutive scale, the waves traveling at the rate of about one to two feet in a second, and only reaching to a distance of a few inches till their headway is entirely checked by the density of the surrounding air! But while this very circumscribed effect on the air is taking place, the sound of the fork is heard throughout the room, thus demonstrating that the fork's action on the air is but the *incidental* effect of its vibrations, and has nothing whatever to do with the *sound-pulses* generated by the molecular action brought into play in consequence of the sudden stops and starts of the sounding body itself. (See the law of sound-generation, for the first time given, in *Evolution of Sound*, p. 93.) Having thus, by a demonstrative scientific test, proved that the air-waves sent off by the so-called "instantaneous pulses" of a sounding body are not the sonorous pulses which we *hear* and call *sound*, I now return to take my final leave of Prof. Brockett, by showing from his review, and in the most unmistakable language, that he not only contradicts himself again, but that he flatly contradicts Professors Tyndall, Helmholtz, and Mayer, as well as every acoustician who has written on the subject of sound, thus deliberately renouncing the wave-theory. He contradicts himself by first teaching that atmospheric sound-waves do really *travel* at the observed velocity of sound, and immediately after by declaring that they *do not travel at all, but stand perfectly still!*—showing that the law of self-stultification is an inherent principle of the wave-theory, by whomsoever advocated.

Look at the explicitness of his language. Speaking of a vibrating "elastic" body, he says that it "sets in motion sound-waves that *pass from the elastic body* as a center *outwards in all directions*," thus clearly teaching that these sound-waves actually *travel* or *advance* through the air. Again, to the same effect: "The more homogeneous the air is, the better medium is offered to the *progress of the sound-wave*," thus unmistakably teaching—as do Tyndall, Helmholtz, and all writers on sound—that these waves really *travel* from the "elastic body as a center *outwards in all directions*." But Prof. Brockett would not be himself, nor would he be consistent with the incongruous theory he advocates, if he did not upset this entire statement. Hence, as just charged, he declares in the most positive manner that these air-waves do not *travel*,—do not "*pass* from the elastic body as a center *outwards in all directions*" at all, but *stand perfectly still where they are made!* Be not amazed at this damaging arraignment. Here is the proof, in his own words:—

"At every pulse of an *elastic* body a spherical globe of air is made at the body, that vibrates to and fro, *but does not advance.* * * * This sound-wave sets in motion—*forms—another sound-wave, and it another, and so on*, sometimes to the distance of many miles. When, then, we hear the sound of a bell, miles away, or the whistle of a locomotive, *it is not the sound-wave that was made at the place where the bell or the locomotive is*, but it is the *sound-wave made of the air where the listener is.*"

Thus we have not only one of the most clearly defined self-contradictions conceivable, but we have at the same time one of the most astounding absurdities ever announced in support of this constitutionally absurd monstrosity of physical science called the undulatory theory. Let us analyze it for a moment, and endeavor to comprehend its enormity.

In the first place, we are assured that a "sound-wave," constituted of a "spherical globe of air" and made by an "*elastic* body" like a "bell," remains stationary where "made," since it "*does not advance*"; but before this "spherical globe of air" gives up the ghost it "*forms* another sound-wave" (without any assistance from the "*elastic* body") which also "*does not advance*," but proceeds to *form* another wave, "it another, and so on, sometimes to the distance of many miles." Thus all these thousands of spherical globes of air, extending in a line for "many miles," are entirely independent of the "elastic body," except the one "*at the place where the bell or the locomotive is*," since each one of the entire lot was *formed* by the "globe of air" next behind it! There is no mistake about this being the truthful representation of the idea conveyed in this lucid and inimitable eclaircissement, because the "sound-wave *made of the air where the listener is*" he positively assures us is not "the sound-wave that was made at the place where the bell or the locomotive is," because that wave "*does not advance*"!

Well, now, I ought to give up my opposition to the wave-theory of sound, after encountering such a new and stunning philosophical revelation as this; for of what avail can "a great flow of language" be in checking the resistless sweep of such a logical avalanche, or in attempting to dam the concentrated torrents of such a cataclysm of natural philosophy? A new Pythagoras has burst upon the world! An apotheosized oracle has dropped into our midst, whose etiolated robes scintillate with the burnished spangles of physical science, and the corruscations of whose luminous genius have thrown into hopeless tenebrosity the achievements of Helmholtz and Tyndall, as the incandescent radiance of the electric light pales the ineffectual glow of a tallow dip!

But I have caught my breath; and, by properly shading my eyes, will try to stand in the presence of this new beacon of science. I will first quote Prof. Tyndall, to ascertain what the wave-theory really teaches, and thus find out whether sound-waves do or do not "advance":—

"Imagine this tuning-fork vibrating in free air. *At the end of a second* from the time it commenced its vibrations, the *foremost wave would have reached a distance of* 1090 *feet* in air at *the freezing temperature*," &c.—*Lectures on Sound*, p. 69.

Prof. Brockett says, Pshaw! Tyndall, you are "not *au fait* in the science of acoustics"; if you were, you would know that sound-waves do not "advance" at all, but stand perfectly still where they are "made," and that "the foremost wave," instead of *reaching* to a distance of 1090 feet in a second, is engaged in the new scientific process of *forming* another wave "at the place where the bell or the locomotive is"!

Tyndall again says in reply:—

"*Imagine* one of the prongs of this vibrating fork *swiftly* advancing. It compresses the air immediately in front of it. * * * The whole function of the tuning-fork is to carve the air into these *condensations* and *rarefactions;* and they, as they are formed, *propagate themselves in succession through the air.*"—"Figure clearly to your minds a harpstring vibrating to and fro; it *advances*, and causes the particles of air in front of it to crowd together, thus producing a *condensation* of the air. It retreats, and the air-particles behind it separate more widely, thus producing a *rarefaction* of the air. * * * In this way the air through which the sound of the string is propagated is moulded into a regular sequence of *condensations* and *rarefactions*, which *travel with a velocity of about* 1100 *feet a second.*" (See all these quotations and many more to the same point, *Evolution of Sound*, pp. 78, 79.)

But Prof. Brockett, no doubt disgusted with Tyndall by this time, may entertain a higher estimate of Prof. Helmholtz as an acoustician. We will therefore briefly consult him:—

"Suppose a stone to be thrown into a piece of calm water. Round the spot struck there forms a little ring of wave, which, *advancing* equally in all directions, *expands to a constantly increasing circle.* Corresponding to this ring of wave, *sound also proceeds in the air* from the excited point, and *advances* in all directions as far as the limits of the mass of air extend. *The process in the air is essentially identical with that on the surface of water.* * * * * The *waves of air, proceeding from a sounding body, transport the tremor to the human ear exactly in the same way as the water transports the tremor produced by the stone to the floating chip.*"—*Sensations of Tone*, p. 14. (See this citation analyzed p. 318 *Evolution of Sound.*)

Now, as Prof. Brockett would not pretend to say that *water*-waves do not "*travel*" or "*advance*," and as he would not dare to assert that these authorities do not correctly expound the current hypothesis, he has clearly abandoned the wave-theory of sound, since Prof. Helmholtz, who is undoubtedly '*au fait* in the science of acoustics," declares that air-waves "advance" "*exactly in the same way*" as do water-waves!

Finally, to sum up the argument and settle the overthrow of the undulatory theory, so far as Prof. Brockett is concerned, I will say, that while he admits that *sound travels* or *advances* from the sounding body to the listener, even if "miles away," he just as distinctly declares that the "globe of air" "does not advance" from the "elastic" body at all, but stays right where it is "made," thus clearly admitting that these "soap-bubble" air-waves do not constitute sound! Being thus utterly self-stultified, as well as voluntarily placed in opposition to all writers on sonorous phenomena, ancient or modern, while at the same time entering the arena of criticism as a champion of the wave-theory, you know just how much faith to place in his present review of *Evolution of Sound*, even if you had no other guide to go by. And you can rest assured that should any others of the great lights of physical science in our colleges and universities venture to put themselves on record by attacking this book and defending the wave-theory against the arguments therein advanced,—even should it be Professors Tyndall, Helmholtz, and Mayer, themselves,—they would fare no better than has Prof. Brockett. The difference, however, is, *the three eminent authorities just named know better than to touch the work, while Prof. Brockett had to learn.*

Really, I need not despair of my reviewer yet becoming a convert to the corpuscular hypothesis, since he has made the essential preliminary move in that direction by totally abandoning the wave-theory. The only obstacle in the way of a consummation so devoutly to be wished, is his startling lack of scientific discrimination; and, judging from the specimen criticism here examined, it is a question of doubt whether this defect in his early education, or in the make-up of his mental organism, may not prove a fatal obstruction.

The serious truth is, although professors of physical science ought to be the most competent of any educated class of thinkers to judge correctly on this subject, and should be the first to evince a readiness to accept any new advance in scientific research, they are, as a general rule, about the last men who may be expected to give in their adherence to a new truth which tends in any degree to force them out of the smoothly worn grooves of scholasticism which, for years, have guided the wheels of their mental machinery. I may, therefore, reasonably expect just such sciolistic opposition as exhibited in this initial attack from a few professors of physical science, at least till such time as they shall be coerced out of their beaten ruts of thought by invincible argument, or possibly till a general change of scientific views occurs, as new investigators come upon the stage.

While this is a just explanation, so far as it goes, of the backwardness of physical investigators to fall in with new scientific discoveries, there is another cause even less creditable. A teacher of formulas laid down by standard authorities, and who has for years drilled and lectured his classes to believe in certain laws and principles of science as mathematically established, is not apt to show much alacrity in coming out before the same classes (unless he is more severely true to himself than my present critic appears to be), and confessing himself an ignoramus for all these years, and that he has been teaching them the most puerile nonsense for philosophical truth. It is well, however, for the cause of scientific research and the advancement of true knowledge, that there are noble and honorable exceptions to this rule, and plenty of them, who are not ashamed to become fools that they may be wise, and whose testimony in favor of the correctness of the new position on sound, though in direct opposition to their lifelong convictions,—like the State's evidence of a criminal which condemns himself,—must be received in preference to interested and biassed opinions of a legion like the one I have the honor of answering.

The new hypothesis of astronomy, formulated by Copernicus, is an illustration exactly in point. Although self-evident on its face, it was at that time scouted as "a total failure" by the Professor Brocketts of the Ptolemaic school, because it came in conflict with a long-established theory of science; and if we will read those controversies we will see almost the precise language used in this review, namely, that the views of Copernicus could not be correct, because the old system of astronomy had been "established mathematically," and that "all the phenomena" of the motions of the heavenly bodies "have been examined in connection with

the current theory, and mathematical formulas have been applied in the most rigid manner; and, in every instance (sometimes correcting errors, however,) the theory has proved sufficiently able to meet every case." Yet it is a matter of record that the ridiculed theory of Copernicus triumphed, and the "mathematically" established theory of the Ptolemys went down with a crash. I wonder if Prof. Brockett ever read of Copernicus!

One would really think that modern physicists, knowing the lesson taught by the disastrous overthrow of the Ptolemaic system of astronomy, would be a little cautious in jeering at any announcement in science, however apparently preposterous, without a careful examination of its claims.

But there were a few Galileos of those days, as there are now, who had the mental force to lift themselves out of the scholastic grooves of that venerable nonsense so long fastened upon the world by professors of mediæval philosophy. I solemnly declare, as my conviction, that there are to-day scores of professors of physical science (judging from letters I am receiving), installed in the chairs of our colleges and universities, who, for bigotry and fogyism, can discount the most opinionated religionists of the dark ages. Though it is well for the cause of the world's intellectual progress that all or even a majority of scientific investigators do not come within this category; for we can congratulate ourselves upon the fact that there are investigators of *truth*, both in science and in religion, who are not afraid to acknowledge its claims in whatever new garb it may appear, or whatever new message it may have to deliver.

In conclusion I wish to say that it is not claimed nor pretended that *Evolution of Sound* is free from minor errors. It must be borne in mind that it is the first work ever written on that side of the question, having no previous investigations to guide the writer's pen; and it would be more than a miracle if the author, who makes no pretentions to a scientific education,—only to a common-sense view of the subjects discussed,—should not have written some things needing correction, even if his arguments in the main should prove to be correct. And it will no doubt prove a Godsend to the advocates of the undulatory theory of sound if there should be found a few such inaccuracies, to be seized upon as straws by the drowning hypothesis before it sinks out of sight.

But the case is entirely different with the wave-theory of sound, which has been a subject of investigation for hundreds of years. It has been written upon and elaborately explained, in all its details, a thousand times, and by the ablest scientists the world has ever produced; and there is, therefore, not a shadow of excuse, if the theory be true, for the transparent absurdities and self-contradictions which abound everywhere in these writings, and which can only be accounted for on the supposition that the current hypothesis is fundamentally false and intrinsically self-stultifying.

I now ask those professors of physical science, therefore, who shall in the future feel it their duty to attack *Evolution of Sound*, not to skip "here and there," and try to find some trifling defect in the use of scientific terms, or even some well-founded objection to the author's "egotistical" style; but to grapple with the main arguments advanced against the wave-theory, and either answer them or admit their impregnability.

Let them, for example, squarely face the problem of a certain species of locust shaking four cubic miles of air into condensations and rarefactions by the motions of its legs, thus generating heat enough to add "*one sixth*," or 174 feet a second, to the velocity of its sound throughout this vast area, and exerting sufficient mechanical power to actually oscillate—bend "once in and once out"—400 times a second, 2,000,000,000 tons of tympanic membranes, as demonstrated to be the case, if there is any truth in the wave-theory. (See *Evolution of Sound*, pp. 129, 175, &c.)

Let them grapple with the problem of magazine explosions, as explained by Prof. Tyndall, in which it is absolutely shown, that, according to the wave-theory, *houses*, and even *horses*, *cattle*, and *human beings* have been blown to atoms by a "*sound-pulse*," no distinction whatever being possible, according to the current theory, between a compressed air-wave, caused by the explosion, and its accompanying sound. (See pp. 103, and onward.)

Let them grapple with the arguments against the foundation-law of "interference," without which the wave-theory of sound confessedly has no existence, and in which Prof. Tyndall's explanations of the double-siren, the sounding of two forks half a wave-length apart, thereby causing neutralization of their waves, and the division of a stream of sound into two branches by the Konig instrument, are disastrously exposed, and turned against the theory. (See pp. 186, 280, 307, &c.)

Let them explain away the startling analogies, as presented at the close of Chapter V., existing between *odor*, *sound*, and *light*, which demonstrate that if one is the result of corpuscular emissions and not wave-motion, as all science agrees, the others must be also. (See pp. 223 to 230.)

Finally, without naming a score of such insurmountable objections urged against the current theory, let them grapple with the very law of wave-motion, in which the most conclusive proof is for the first time given, that the velocity of all waves must be in proportion to wave-length, while all sounds travel at the same uniform velocity, whether high or low in pitch, and consequently whether the theoretic wave-lengths be long or short, thus showing that sound does not travel by wave-motion at all. (See pp. 317 to 326.)

Until these crushing considerations are taken up and disposed of by advocates of the undulatory theory, it is worse than a waste of valuable time to talk and write, as does my learned reviewer, about the "instantaneous pulses" of a tuning-fork's prongs sending off *air-waves* 1120 feet in a second. And, I hereby give due notice to all such sapient critics, let them call it "egotism" or what they like, that the author of *Evolution of Sound* does not propose to remain an idle spectator, and allow them to reiterate their stereotyped and nonsensical "condensations," "rarefactions," "superpositions," and "instantaneous pulses," while at the same time deliberately ignoring the overwhelming arguments against their theory, just enumerated, which glare at them from those humble pages like so many burning mountains.

Again thanking you for the interest you have taken in my work, I am sincerely yours,

WILFORD.

Problems Propounded by Prof. I. L. Kephart, A.M.,

For five years Professor of Natural Science and History in Western College, at Western, Linn Co., Iowa.—Wilford's Reply.—Prof. Kephart's Final Response, admitting the Undulatory Theory to be "Hopelessly Shattered."

LEBANON, Pa., Jan. 16, 1879.

WILFORD (Care of HALL & CO.)

Dear Sir: I have read your *Problem of Human Life* with pleasure; and what I admire most is your demonstrative evidence of the fundamental truths of religion—the existence of God, and the substantial and conscious nature of the soul—upon purely scientific grounds, and without in the least depending upon the Bible for your proofs. This is what the scientific world has long needed; and in this respect I regard your work as a Godsend to this age.

There is, however, a single point in your argument on Sound to which I beg leave to call your attention, as it is in direct conflict with all we have been taught on the subject in works on Natural Philosophy and Physics; and unless you are able to explain it satisfactorily, and harmonize the phenomena involved with your views as published in *Evolution of Sound*, it must prove a serious stumbling-block in the way of many persons accepting your otherwise strong assaults upon the undulatory theory. But let me assure you that in presenting this difficulty, I do so only out of a desire for information and not for the sake of criticism.

Natural Philosophy, or rather Physics, teaches (and I think correctly, too,) that a *pebble*, dropped into the ocean, actually stirs or displaces the entire mass of its water. Of course, you deny this; because, on page 113 of your book, you ridicule, as a philosophical absurdity, the idea that a man, by thrusting his finger into the water, stirs the whole ocean, or produces any effect on the water, except to a very limited distance around.

Now, you will readily admit, if the problem here suggested can be shown to be correct, that it seriously weakens your argument based on the stridulation of the locust shaking four cubic miles of air with a force sufficient to vibrate 2,000,000,000 tons of tympanic membranes, which I admit you show must occur, according to the wave-theory of sound. As you will necessarily deny the correctness of this pebble difficulty, allow me to prove it.

To make the matter plain, we will confine the illustration to a less body of water than the ocean, and to a cubic foot of *lead*, instead of a *pebble*. We will assume that we have a *tank* that is 1000 feet long, 1000 feet wide, and 1000 feet deep, and that it consequently holds 1,000,000,000 cubic feet of water; and, when it is filled, the upper water surface of the tank is exactly 1,000,000 square feet. This volume of water, then, weighs (counting 62 pounds to the cubic foot) 62,000,000,000 pounds, or 31,000,000 tons. Now, if a cubic foot of lead (weighing 704 pounds) should be dropped into this tank, it will certainly stir or displace every particle of this mass of water; for it will sink to the bottom, and cause the water to rise one one-millionth of a foot in the tank. This is surely not a "philosophical absurdity."

Then, the question is, did or did not the cubic foot of *lead*, by being dropped into the tank and raising the entire mass of water, exert a force equal to 31,000,000 tons? I think (upon the principles of hydraulic pressure, as explained in the second edition of "Snell's Olmstead's Natural Philosophy," pp. 133–4,) that it did; and may not the wonderful force which (as you so clearly prove) the locust exerts, according to the wave-theory of sound, be accounted for in the same way? In other words, if a cubic foot of lead can exert a force of 31,000,000 tons on the water of this tank, displacing or stirring its 1,000,000,000 cubic feet, it proves the correctness of the principle that a *pebble* must, on being dropped into the ocean, displace and agitate its entire mass of water by raising its level to the equivalent of the pebble's bulk. And if so, what is to hinder a locust shaking the air throughout the entire area permeated by its sound? You undoubtedly see the pertinence and force of this difficulty.

I shall be much gratified if you can succeed in solving these problems of the *pebble* and the *tank* satisfactorily, and harmonizing them with your positions on sound; and I have no hesitation in saying that if you can fairly do so, that your arguments against the wave-theory are unanswerable.

Hoping to hear from you on the subject, I am, very respectfully yours,

I. L. KEPHART.

Wilford's Reply.

OFFICE OF HALL & CO.,
NEW YORK, Jan. 24, 1879.

PROF. KEPHART, A.M.

Dear Sir: Your letter of inquiry, calling my attention to certain philosophical difficulties in connection with my arguments against the current theory of sound, came duly into my hands. I am thankful for these suggestions, and for the mathematical argument which accompanies them. Your candid manner excites my admiration, being in such marked contrast to the bitter opposition the book is receiving at the hands of a few professors of physical science, who have not shown the fairness or even the courage to first read the arguments against the undulatory theory of sound before casting the book aside as unworthy of attention.

I therefore take great pleasure in replying to your inquiries; and will try to convince you that the problems of the "pebble" and the "tank" are founded on a radical misconception of the physical laws; and that the standard works on Natural Philosophy and Physics which teach such pitiable nonsense as that a *pebble* can shake the entire ocean, or *a cubic foot of lead* can exert a pressure of 31,000,000 tons on a tank of water, ought to be unceremoniously thrown out of our schools and colleges, and sent to the paper-mills to be ground over.

First, then, let us consider your problem of the "pebble," and the actual effect produced by so small a body sinking into the ocean. It evidently displaces a quantity of water at the surface, directly above and around the spot where it enters, equal to its own bulk. Of this there can be no doubt. I also freely admit that the entire ocean level is disturbed, and must be re-adjusted, since it will be raised to the equivalent of the pebble's bulk, the same as the water in the tank must be raised to the equivalent of the bulk of one cubic foot of *lead*. But then I assert that this disturbance of the ocean's surface level is not produced at all by the mechan-

ical force of the pebble entering the water; and that herein alone lies the error on which this problem is based, and which I will now endeavor to point out.

Writers on Natural Philosophy never seem to think of taking into account, in dealing with such problems as these, that mighty mechanical energy, which always stands ready to act, namely, the universal force of *gravitation*. The moment we recognize this mechanical energy, the difficulty vanishes. When the pebble, for example, has settled below the surface, and has raised the water around and above it to the aggregate of its own bulk, it has done all it has the mechanical power of doing, so far as your problem is concerned. But *gravitation*, ready with its countless millions of tons of physical force, takes up the displaced water where the pebble has left it, just the same as if a drop of water containing that quantity had fallen there in place of the pebble, and proceeds to adjust the ocean and equalize its surface level in conformity with this addition of bulk; and this tireless mechanical energy will go forward in the prosecution of its work till it is finished, even should it require the displacement of the entire ocean to effect it, though it requires nothing of the kind,—the surface only needing to be re-adjusted, as will appear after a little.

Now, I ask you, where is there a work on Natural Philosophy or Physics which says one word about this ever-present mechanical force of gravity as the true key to the solution of such difficulties as these? I venture to believe that there is no such a work to be found, or you would have undoubtedly known of it, and thus been saved the trouble of propounding these problems. No! Writers on physical science, it seems, prefer to leave the student under the impression that a wonderful miracle had been wrought by teaching that a pebble possesses the mechanical force to actually stir the entire ocean; and that, too, without the slightest regard for the necessary relations existing between cause and effect.

As this method of calling to our aid the force of gravity clearly solves the problem, showing that the pebble does nothing in the premises but displace the water at the surface equivalent to its own bulk, there is only one thing for the authors of these standard works on physical science to do, and that is to endeavor to trap me by asking, Since you admit that the ocean's surface was really *stirred*, and that it would not have been thus *disturbed* but for the pebble falling into it, then was not the pebble the *cause* of the mechanical disturbance necessary to bring about this vast re-adjustment? I answer, emphatically, Yes. But here, again, Natural Philosophy needs a shaking up, as such a quibble would make no distinction, in accounting for these physical effects, between the *proximate* or *direct mechanical cause* of a certain result, and the *remote cause* (like that of the *pebble*), which, as I will now show, has nothing to do with the solution of these problems. Let me illustrate.

A mighty boulder may be so poised on the peak of a mountain that a single inch of hard clay may hold the balance of power in sustaining its weight and keeping it in its position. A locust, taking shelter beneath this rock from a rainstorm, may shake from its wings a single drop of water, which, striking this lump of clay at its center of support, so softens it that it yields to the almost infinitesimal fraction of preponderating weight in that direction; and this law of gravity, with its enormous energy, coming into play, takes up the work where the locust left it, just as it takes up the small protuberance of water where the pebble left it, and down goes the boulder, crashing through the forest with the besom of devastation, pulverizing other boulders in its path, and cutting down trees that have stood the mountain blasts of a thousand years!

How shallow would be the natural philosophy which, leaving out of the account this mechanical force of gravity, coolly tells the student of science that because the shaking of this locust's wings was the remote cause of the boulder falling, an insect, therefore, has sufficient mechanical power in its wings to break down trees ten feet in diameter! Yet this is substantially what your difficulty of the *pebble* implies, and what our standard works on physical science teach. Is it any wonder, then, that an uneducated writer, whose common sense leads him to detect the prodigious absurdity of such teachings as these spread out in our standard authorities on science, should be carried somewhat to the extreme in slapping right and left the authors of such works? I pardon the author of *Evolution of Sound* for sometimes losing his temper.

The true explanation of the matter is simply this: The pebble displaces its bulk of water at the surface as it enters, which displacement gravity adjusts, in the manner already explained, in order to equalize the surface level of the ocean,—while the *pebble*, in sinking, produces no effect on the mass of the ocean except displacing the water directly in its path, or that which comes in contact with it, and which, by the mobility of its particles, passes from below, taking its place above as the pebble settles. The effect on the water by the *pebble* sinking, after it is once below the surface, is the same as that of the moving *fin* of a fish. It adds nothing to the bulk of the water; and hence the effect of such disturbance does not require adjustment at a distance, because it does not extend further than required to transfer the water from one side to the other as the fin or the pebble advances.

So, also, is it with the stridulation of the locust. It is already in the midst of the ærial ocean; and, as it adds no corporeal substance to the mass of the air by singing, there is no adjustment of the atmosphere at a distance necessary, requiring gravity to come into play, as when the bulk of the pebble is added to the ocean, or as when a quantity of gas is generated and added to the air at a magazine explosion. Hence, the trifling vibratory movement which generates the music of the locust can produce only a direct mechanical effect upon the surrounding air to a distance in exact proportion to the limited physical strength of the insect, and which disturbance the mobility of the atmospheric particles re-adjusts, without the mechanical effect extending, possibly, half a dozen inches from the locust. This motion of its legs, therefore, can not produce such an effect upon the air as to be even a *remote* cause for gravitation to come into play at a distance.

In regard to the "tank" problem, I desire to say that if "Olmstead's Natural Philosophy," or any other work on physical science, teaches that a cubic foot of lead can exert a pressure on the tank or the water it contains of 31,000,000 tons, it inculcates a scientific fallacy only surpassed in absurdity by the supposed possibility of a locust exerting the me-

chanical force attributed to it by the wave-theory of sound, or of a pebble displacing the entire ocean by sinking into it.

The real mistake in writers on physical science, who inculcate such *unnatural* philosophy as this tank problem teaches, is in supposing that the cubic foot of lead displaces its bulk of water at the *bottom* of the tank instead of at the *top* where it enters, which would, in such a case, of course add one one-millionth of a foot thickness all over the bottom; and consequently would lift the entire mass of water that much higher in the tank, thus exerting, as you have supposed, a force of 31,000,000 tons. Such a stupid performance, however, on the part of this cubic foot of lead, would evince about as much mechanical shrewdness as was exhibited by the *farmer* who rigged machinery in his barn to windlass his horse up into the haymow to keep him from starving, never thinking that the hay might be thrown down to the horse! The author of a work on Natural Philosophy who could deliberately write out and publish such a preposterous principle of science as that the cubic foot of lead waits till it gets to the bottom of the tank before producing its displacement, for no apparent reason but to exhibit its physical strength in lifting the whole 31,000,000 tons of water, would undoubtedly, in a fair contest with this farmer, carry off the first prize for absurdity.

It is perfectly plain that the cubic foot of lead, by settling into the water, displaces its bulk at the top where it enters, and thus adds, through the assistance of gravitation, the one one-millionth of a foot of water as a top layer all over the surface after adjustment has taken place, the same precisely as if such a thin sheet of water had distilled from heaven into the tank in the form of dew; and it is indisputably clear that such a layer, by no possibility, communicates any more pressure to the tank than it adds to the weight of the water already in it, namely, one cubic foot, weighing 62 pounds, the foot of lead having nothing to do with this pressure as it rests on the bottom with a weight of exactly 642 pounds, which is the weight of the lead minus the weight of the cubic foot of water it displaces. Thus the sinking mass of lead acts on the water, after being once submerged, the same precisely as does the *pebble* in sinking into the ocean, causing no displacement except of the water immediately in its path and to a limited distance around, sufficient only to cause an equilibrium as the lead advances.

Although this exposition of the "pebble" and "tank" problems, it seems to me, can admit of no question or doubt in the mind of any man who will reason on the subject, or who will take the trouble to shut up his standard authorities for one minute, and look at the question as if it had never before been discussed,—yet it is a fact that, for the want of this mental independence, professors of physical science are teaching students all over this land the very absurdities involved in these problems as philosophical truth, just because they happen to be laid down in some standard work as a mathematically established principle of science. And for the same reason (the want of a little self-reliant thought) these responsible teachers lecture their classes on the beauties of the undulatory theory of sound, which involves the monstrous impossibility of an insect mechanically and directly compressing four cubic miles of air by the movement of its legs, and thereby generating heat enough throughout this vast area to add "one sixth," or 174 feet a second, to the velocity of its sound!

Yet some of these investigators are the very men who pass judgment on *Evolution of Sound* without even reading a single argument it contains; and then *egotistically* condemn the "egotism" of the author, and brand him a "sciolist" and "lunatic," as a number of recent letters from colleges bear witness, because he had the presumption to call in question a theory which absolutely and undeniably teaches that an *insect* possesses the physical energy of more than a million horses!

I do not deny but that it looks *egotistical* in the extreme for any "*one man to pit himself against the whole scientific world*" by attempting to break down an established theory of science which has held undisputed sway for hundreds of years. But then, what is to be done about it, supposing the "one man" should happen to be right, and the whole scientific world wrong? Would it still be "egotism"? Such a thing has occurred before, and might possibly occur again, which makes it a risky business for professors of physical science to *call names*, in lieu of a candid investigation of the new hypothesis and the arguments advanced to sustain it. For should these physicists, who make such undue haste to commit themselves on the popular side, happen to be *mistaken* in the present case, as good judges are beginning to acknowledge them to be, they can ill afford to face their record in the future, while the "one man" can very well afford to go into history as the "egotist," "lunatic," or even "idiot," who, single-handed and alone, succeeded in overturning a theory which had received the unanimous endorsement of the scientific world for centuries. I can afford to wait for the final verdict.

Hoping that the explanations here given of your problems of the "pebble" and "tank" may prove satisfactory, I am, very truly yours,

WILFORD.

LEBANON, Pa., Jan. 28, 1879.

WILFORD (Care of HALL & CO.)

Dear Sir: Your kind and highly interesting letter, containing your answer to my inquiry, was received two days ago, and read with great pleasure and with *entire satisfaction*. I would have replied sooner, but I desired, before doing so, to consider your letter thoroughly. I also took the liberty of showing it, with your other letter to me, to Prof. L. McFadden, of Lebanon Valley College, and fully acquainting him with the whole matter of our correspondence. He is a young man whose father is Professor of Natural Science in Otterbein University, at Westerville, Ohio (my *alma mater*). The young Professor purchased one of your books (through my recommendation), read it hastily through, and during a short vacation visited his father, and left the volume with him to read. He is very much interested in it; and, on reading your last letter, containing your solution of the "tank" and "pebble" problems, he expressed a desire to have his father see it. I took the liberty of granting him the privilege of sending it to him; so your letter is now on its way to Otterbein University, but will be returned to me again. Pardon this liberty, as I have acted with a desire to aid your work.

I wish now to say that your letter has fully satisfied me that the "pebble" problem is false, as well

as the "tank" problem. Your reasoning is perfectly conclusive to my mind that the authorities which teach such principles of philosophy and physical science are wrong; and consequently I have no hesitation in admitting that, in my opinion, *the undulatory theory of sound is hopelessly shattered.*

Indeed, I wish to state, right here, that your first letter to me, after you had received the problems, in which you so positively asserted your ability to prove them *false*, set me to thinking on the matter. Previously I had, as I suppose most students do, simply taken what the books taught respecting these things as science and fact, without stopping to question their correctness. But, as already stated, your letter set me to *thinking*, as to the correctness of the "tank" problem; and on the evening of the day before I received your explanation, I had arrived at the conclusion that it must be *false;* and so expressed myself to my son, who is now a senior in the classical course of Lebanon Valley College. In discussing the matter with him, I entered into a careful calculation of the physical and mechanical questions involved; and I assure you that my method of explaining the falsity of the "tank" problem, and the actual change effected by inserting the cubic foot of *lead*, was in many respects exactly like your own. I am, therefore, fully satisfied that your reasoning is sound; and that the works on physical science which teach the contrary are wrong. I am consequently now prepared to drop the undulatory theory of sound as a *monstrous absurdity.*

I will be pleased to aid you in your fight, so courageously inaugurated; and, if at any time you see where I can be of service to you, please inform me, and command my services.

Most respectfully yours,

I. L. KEPHART.

In another letter to WILFORD, dated Feb. 11th, Prof. KEPHART says:—

"I am glad to learn that there are a few investigators of physical science who can lay aside their prejudices, and give your arguments a candid reading. All such must be convinced that the undulatory theory of sound is a scientific delusion, and wholly without foundation in fact. I am still reading *Evolution of Sound*, and the more I examine it the greater is my astonishment that the wave-theory should ever have been accepted as correct, much less that it should have been believed in for centuries by so many eminent men. * * * * * Sincerely yours, I. L. KEPHART."

The following letter from Dr. ADAMS, President of the Illinois Wesleyan University (one of the largest educational institutions of the West), is a sample of others we are receiving, and indicates the gathering storm which is about to burst upon one of the established theories of science:—

BLOOMINGTON, Ill., Feb. 6, 1879.

HALL & CO., 234 Broadway.

Gentlemen: I have examined the new theory of sound, or, rather, as it seems to me, the *complete overthrow* of the "undulatory theory." Other members of the Faculty have come to the same conclusion with myself. We are all very anxious to read WILFORD'S entire work. Please send me the *Problem of Human Life*, complete, with bill, and oblige yours truly, W. H. H. ADAMS.

Opinions of Eminent Clergymen.

The following is from the article of Rev. Dr. DRINKHOUSE, editor of the *Methodist Protestant*, Baltimore, Md., referred to by Prof. BROCKETT at the close of his review:—

"He leaves nothing untouched, evades nothing, but follows the champions of the theory through all the windings of the intricate subject. He brings together an immense amount of matter; and this portion of the book is worth the reading, if for nothing but its fair condensation by a scientific mind of Darwinism in all its phases. * * * The *finale* is the utter breakdown of the theory of evolution. * * * We do not think it possible to discount the force and conclusiveness of Wilford's arguments. In our judgment it is the ablest and most timely production since the appearance of Bishop Butler's 'Analogy,' in 1796. * * * No one wishing to keep abreast with the thought of the times upon the gravest subjects which can possibly challenge human attention, can afford to neglect the careful study of this work."

Rev. Dr. BATES, in the same paper, writes as follows:—

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"L. W. BATES."

The weight of this commendation will be appreciated when it is understood that Dr. BATES is the President of the Convention of the Methodist Protestant Church, and consequently the highest officer in that denomination.

[*From The Standard, Chicago.*]

"'Wilford' is the *nom de plume* behind which some keen and scholarly writer conceals his identity. The motive for concealment is not like that which might well have actuated 'Junius,' but rather to put forth the book on its own merits, without the aid of name and reputation. The author is justified in thinking that the theories advanced and the positions taken are striking enough to command attention solely on their own account."

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